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सतःआच्छादित कृषि हेतु संरचनायें — कुहासा कक्ष का संस्थापन और संचालन — मार्गनिर्देश

Indian Standard

SURFACE COVERED CULTIVATION STRUCTURE — ESTABLISHMENT AND OPERATION OF MIST CHAMBER — GUIDELINES

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Agricultural Produce Processing and Milling Machinery and Surface Covered Cultivation Structures Sectional Committee, FAD 61

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Agricultural Produce Processing and Milling Machinery and Surface Covered Cultivation Structures Sectional Committee had been approved by the Food and Agriculture Division Council.

Mist chambers have been established and used for plant propagation work for several decades. The mist chambers create favourable conditions of light, temperature and humidity for vegetative propagation of plant material. However, there have been large variations in the type of structures, misting systems and their operations. These variations often differentiate between success and failure. The present effort is being made to rationalize the installation and operation of mist chambers so that prospective users could take correct decisions.

In the preparation of this standard considerable assistance have been derived from Indian Agriculture Research Institute, Pusa, New Delhi.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SURFACE COVERED CULTIVATION STRUCTURE — ESTABLISHMENT AND OPERATION OF MIST CHAMBER — GUIDELINES

1 SCOPE

This standard covers the guidelines for establishment and operation of mist chambers.

2 PRINCIPLE OF MIST CHAMBERS

The objective is to minimize the difference in pressure between water vapour in the leaves (V_{leaf}) and that in the surrounding air (V_{air}) either by decreasing V_{leaf} through reducing leaf temperature (that is, with intermittent mist) and/or by increasing the V_{air} by preventing the escape of water vapour (that is, with an enclosure). Enclosed systems use humidification since only V_{air} is increased, while intermittent mist operates primarily on V_{leaf} but also provides a modest increase in V_{air}.

Mist systems have been used in propagation to lower the leaf-to-air vapour pressure gradient and slow down leaf transpiration. Mist also lowers ambient air temperature and the cooler air consequently lowers leaf temperature by advection in addition to the cooling occuring through evaporation of applied film of water.

Enclosed mist utilizes polyethylene-covered structures in glasshouses that reduce the fluctuation in ambient humidity that are common to open-bench mist. Enclosed mist also ensures more uniform wetting of foliage since air currents are reduced. There are advantages in using enclosed mist with difficult-to-root species compared to open mist or the greenhouse system without mist.

Major advantages of enclosed systems are their simplicity and low cost. The main disadvantage is that they trap heat if light intensity is high. The trapped heat increases the saturation deficit of the air, and leaf temperature rises to increase the leaf-to-air vapour pressure gradient and consequently leaves lose water. Shading must be used with these systems. Polyethylene films have a low permeability to water vapour loss, but allow gas exchange. They are used to cover outdoor propagation structures as well as for closed mist systems in greenhouses

3 MICROCLIMATIC PARAMETERS

3.1 Temperature

The consensus regarding the optimum medium temperature for propagation is 18 to 25°C for temperate climate species and 7°C higher for warm climate species. Day-time air temperatures of about 21 to 27°C with night temperatures about 15°C are satisfactory for rooting cuttings of most temperate species, although some roots better at lower temperatures. High air temperatures tend to promote bud development in advance of root development and thus increase water loss from the leaves. It is important that adequate moisture status be maintained by the propagation system so that cuttings gain the potential benefit of the higher basal temperature.

3.2 Light

Light is a contributing factor in adventitious root and bud formation of cuttings. Cuttings of certain herbaceous plants, such as chrysanthemum, geranium and poinsettia rooted better in tests when the irradiance increased to 116 W/m^2 during trials in winter months. Very high irradiance (174 W/m^2) damaged leaves on the cuttings, delayed rooting and reduced root growth. With selected temperate species, acceptable light ranges are 20 to 100 W/m^2 per day.

3.3 Day Length (Photoperiod)

In some species, the photoperiod under which the cuttings are rooted may affect root initiation, long-days or continuous illumination generally being more effective than short-days, although in other species photoperiod has no influence.

3.4 Quality of Radiation

Radiation in the orange-red end of the spectrum seems to favour rooting of cuttings more than that in the blue region but there are conflicting reports for stock plants.

3.5 Carbon Dioxide Level

In order to maintain CO_2 levels in favourable range, provision for aeration shall be provided.

4 ENVIRONMENTAL CONDITIONS REQUIRED IN MIST CHAMBERS

4.1 For successful propagation, some essential environmental requirements are given below:

a) Media temperature, 18 to 25°C for temperate species and 7°C higher for most tropical species.

b) Atmosphere conducive to low water loss and maintenance of turgor in leaves.

c) Ample, but not excessive light, 20 to 100 W/m^2 with selected temperate woody species (exceptions are with species propagated under full sun in outdoor mist beds).

d) Rooting medium should be clean, moist, well-aerated and well-drained. It should be effectively sterilized through steam, chemicals or solarization to obviate the problem due to soil borne infections. Solarization is the process of root medium sterilization through the use of solar radiation. The wet medium rises is heaped under sun in 10 to 15 cm thick layer which is covered with a transparent polyethylene sheet (50 to 100 μm thick). The temperature in the root medium rises due to the greenhouse effect to 50 to 55°C and the soil gets sterilized after 4 to 5 weeks.

e) Water used in the mist chamber should be free from sand or debris. Water high in salts, such as sodium or potassium carbonate, bicarbonate or hydroxide can be detrimental especially when coupled with low levels of calcium. Complete water analysis including *p*H, total soluble salts, SAR, EC, total carbonates, etc, should be taken to correct the water quality.

4.2 Either misting or fogging systems can be used to create the required environmental conditions.

5 MISTING SYSTEM

5.1 Nozzles

5.1.1 *Selection* — The choice of mist nozzles should be based on the following parameters:

a) cost;

b) maintenance;

c) convenience in operation;

d) availability from suppliers;

e) size of mist droplet (ideally, 50 to 100 μm, enabling water to be suspended as a cloud for a few seconds);

f) amount of water used (fine orifice mist nozzles use less water but clog-up more readily); and

g) mist pattern (sufficient coverage but avoiding overwetting media).

5.1.2 *Types*

The following two types of nozzles are mainly used in mist chambers.

5.1.2.1 *Oil burner type or pressure jet or whirl nozzle*

In the oil burner type, water is forced under pressure through small grooves set on angles to each other, which produces a mist when water exits the orifice. There are improved designs operating under lower water pressures, which are non-dripping and self cleaning. Many of these nozzles have a low water output of 9 to 20 l/h. Pressure jet nozzles have curved internal grooves, and when pressurized water is forced through the grooves, the impact at the orifice of the nozzle breaks up the water flow into mist.

5.1.2.2 *Deflection or anvil nozzle*

The deflection nozzle develops a mist when pressurized water passes through the orifice and strikes a flat surface or anvil. The larger aperture used in this type reduces clogging but uses more water. Again, there are many variations among the two principal types in orifice size and water efficiency. There are also some excellent hard plastic nozzles that are less expensive and more durable than metal ones.

5.2 Controls of Misting System

Intermittent mist during the daylight hours, which supplies water at intervals frequent enough to keep a film of water on the leaves but no more, gives better results than continuous mist. Since it would be impractical to turn the mist on and off by hand at short intervals throughout the day, automatic control devices are necessary. Several types of control devices are available, all operating to control a solenoid (magnetic) valve in the water line feeding the nozzles.

In a mist installation, especially the outdoor type, the cuttings will be damaged if the leaves are allowed to become dry for very long. Even 10 minutes without water on a hot, sunny day can be disastrous. In setting up the control system to provide an intermittent mist, every precaution should be taken to guard against accidental failure of the mist applications. This includes the use of a 'normally open' solenoid valve, that is, one so constructed that if the electric power becomes disconnected, the valve is open and water passes through it. Application of electricity closes the valve and shuts off the water. If an accidental power failure occurs or any failure in the electrical control mechanism takes place, the mist remains on continuously, and no damage to the cuttings results.

5.2.1 *Timers*

Electrically operated timer mechanisms are available that operate the mist as desired. A successful system uses two timers acting together in series-one turns the entire system on in the morning and off at night; the second, an interval timer, operates the system during the daylight hours to produce an intermittent mist at any desired combination of timing intervals, such as six seconds ON and two minutes OFF. Time clocks for regulating the application of water are preferred by many propagators because of their dependability. Some electronic timers are very versatile and can operate many banks of mist nozzles in sequence. Timers have the disadvantage of not responding to daily fluctuation in light intensity, cloud cover, relative humidity and temperature. Although mechanically and electronically reliable, the propagator must make daily adjustments with this equipment.

The danger of electrical shock should always be kept in mind when installing and using any electical control unit in a mist bed where considerable water is present. The complete electrical installation should be done by a competent electrician.

5.2.2 *Electronic Leaf*

In another type of control mechanism, the so-called 'electronic leaf' or 'artificial leaf,' two carbon electrodes are set in a small circular ebonite block and placed under the mist along with the cuttings. The alternate wetting and drying of the terminals makes and breaks the electric circuit which, in turn, controls the solenoid valve. There are several variations in this type of control. In one, a piece of filter paper is used as the sensing material connected between two electrodes. The electronic leaf would theoretically maintain a film of water on the leaves of the cuttings at all times, automatically compensating for hourly and daily changes in the leaf evaporation. The principal defect of the electronic leaf is the gradual buildup of a mineral deposit between the terminals, which will conduct electricity. The leaf must, therefore, be cleaned periodically. The aquamonitor overcomes salt deposit problems since it has an air gap between the electrodes, which can be adjusted.

5.2.3 *Screen Balance*

Another type of control is based upon the weight of water. A small stainless steel screen is attached to a lever actuating a mercury switch. When the mist is on, water collects on the screen until its weight trips the mercury switch, shutting off the solenoid. When the water evaporates from the screen, it raises, closing the switch connection, which opens the solenoid, again turning on the mist. This type of control is best adapted to regions where considerable fluctuation in weather patterns may occur throughout the day, from warm and sunny to overcast, cool and rainy; the unit compensates for changes in leaf evaporation. These units have greater maintenance requirements than time clocks and are prone to salt deposits, algae growth, and wind currents which distort balance accuracy.

5.2.4 *Photoelectric Cell*

Controls based upon the relationship between light intensity and transpiration rate are available. These contain a photoelectric cell, which conducts current in proportion to the light intensity. It activates a magnetic counter or charges a condenser so that, after a certain period of time, the solenoid valve is opened and the mist applied. The higher the light intensity, the more frequently mist is applied. At dawn and dusk very little is used, and at night none. During cloudy days less mist is used than during bright, sunny days. Such a control system would not be well suited for outdoor mist beds, where transpiration is affected by wind movement as well as by light intensity. There may be advantages in using a time clock to override the system at night since photoelectric cells are prone to overwater during cloudy weather and at night.

5.2.5 *Computerized Controllers*

There are computerized propagation controllers that can be programmed to monitor air, media, leaf cutting temperature, light intensity (radiant energy) and vapour pressure differences between air and leaf; the environmental information can then be coupled to frequency and duration of mist needed.

6 FOGGING SYSTEM

6.1 Fog Generators

Fog generators or atomizers produce very fine water droplets, less than 20µm (about one-tenth the size of a human hair). Fog remains airborne sufficiently long for evaporation and subsequently increases relative humidity to 93-100 percent. With fog, water is suspended in the air as a vapour, whereas mist droplets (generally 50 to 100 µm) lose their suspension and fall onto the surface of leaves and media, and condense as a liquid; this liquid from mist cools the leaf surface but leaches nutrients from the leaf and can easily overwet the media. There are many advantages with fog systems; however, they are more costly than mist systems.

6.2 Equipment

Centripetal foggers for ventilated high humidity consist of a self-contained unit incorporating a large fan that forces a stream of air through water ejected from a spinning nozzle. The water is atomized into 30 µm droplets, which are then forced into a cool air stream through the propagation house by a fan attached to the rear of the unit. Like other fog systems, it directly humidifies the air around the cutting instead of wetting the leaf surface. Ventilated high-humidity propagation is successful only when circulation of air among the cuttings is adequate for removing heat generated from sunlight. Greenhouses must be shaded and good fan ventilation is assured. Best results are obtained with an oscillating humidifier that produces a large volume (38 to 190 l/h), of fog with 20 to 30 µm droplets.

With high pressure fogging, water is forced under high pressure (3.4 to 6.9 MPa) through mist nozzles with very fine orifices. The water then hits an impact pin attached to the nozzle, which atomizes droplets to less than 20 µm in size, and subsequently forms a dense fog. Individual nozzles typically put out 5 to 8 l/h and are spaced 2 m apart.

Pneumatic or ultrasonic humidifier nozzles use compressed air and water. Water is broken into fine droplets by passage through a field of high frequency sound waves generated by compressed air in a resonator located in front of the nozzle. In essence, water is being accelerated and atomized to fog. The nozzle orifice is much larger and less prone to blockage than are high-pressure fogging nozzles and outputs range from 20 to 55 l/h.

6.3 Controls of Fogging System

The key to successful fogging hinges on sufficient but not excessive fog, and good ventilation systems to avoid heat buildup from stagnant warm air. Relative humidity sensing is needed for fog systems. Time clocks are not satisfactory for controlling rate of fogging. Most fog controllers operate to maintain a fixed relative humidity, which is the simplest and least expensive option, albeit less than perfect.

7 PREVENTION OF OPERATIONAL PROBLEMS

Difficulties may arise in operating mist systems. Low water pressure can be a problem. Many propagators like to operate with a minimum mistline water pressure of 34.5 N/cm^2 to assure that mist (not drizzle) is produced and that uniform coverage is maintained within the specification and the spacing of the nozzle used. A small, electrically powered rotary booster pump that builds up pressure into a pressurized holding tank assures that mist can be produced instantly on demand.

If there is much sand or debris in the water, filters should be installed in the supply line and strainers, which are checked and cleaned periodically, and should always precede the solenoid valve in a mist line. Fog systems utilize very elaborate filtration systems. (particularly high-pressure fog systems with ultra fine nozzle orifices); chlorination is also included to remove algae.

Algal growth often develops a green coating on and around mist-propagation installations after an extended period of operation. This coating is not directly harmful to the cuttings but is unsightly and because it is very slippery can be a hazard. This slimy material is principally blue-green (*Oscillatoria, Phormidium* and *Arthrospira*) and green (*Stichococcus* and *Chlamydomonas*) algae. Allowing the water to remain off for a period each night so that the mist area can completely dry out will generally hold the algae in check. Algicides, such as Algimine, Algofen (dichlorophen), Algae-Go 36-20, or Cyprex (iodine acetate) can also be used and are effective on mosses and liverworts as well. Algae will reduce aeration of propagation media and create cultural problems.

All propagation media should have sufficient aeration and allow for good drainage. A more porous mix is be needed for a closed mist system or when propagating during the cool winter months compared to the summer with its higher evaporative demands.

The quality of water used in mist can influence the rooting obtained. A complete water analysis should be done to determine *p*H, total soluble salts, SAR (sodium absorption ratio), total carbonates, electrical conductivity, etc. High *p*H is commonly controlled by acidification (acid injection of sulphuric or phosphoric acid) into mist water. Water high in salts, such as sodium or potassium carbonate, bicarbonates, or hydroxides, can be detrimental, especially when coupled with low levels of calcium. Adding gypsum ($CaSO_4$) to the rooting media is one way to partially offset sodium problems. Another option could be switching to a propagation system that requires less water on the foliage (that is, a contact poly system or closed mist *versus* a traditional open mist with greater water demands).

It is better to work with chlorinated or chlorinated mist water, which reduces algae problems and keeps in check some damping-off organisms.

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
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Regional Offices :

		Telephone
Central :	Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17 323 38 41
Eastern :	1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700 054	337 84 99, 337 85 61 337 86 26, 337 91 20
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